

INAUGURAL MEETING OF THE SYDNEY SECTION, AUSTRALIA

A VERY successful meeting to inaugurate the new Sydney Section of the Institution was held in Sydney on March 15, 1938. MR. E. C. PARKINSON, Section President, opened the meeting with a brief survey of the Institution's activities and also of the events leading up to the formation of the Sydney Section.

A message was read from Lord Nuffield, President of the Institution, from aboard the *Orion*, as follows: "Would like to send you my best wishes for entire success of Inaugural Meeting of Institution of Production Engineers."

A paper entitled "The Production Engineer and his Work" was read by Mr. J. M. Steer, Grad.I.P.E., Honorary Secretary of the new Section, and this was followed by a very interesting discussion, in which a number of members and visitors took part.

In opening the meeting, MR. E. C. PARKINSON, Section President, said:—

On behalf of the President of the Institution, Lord Nuffield, I welcome you to-night to the inaugural meeting of the New South Wales Centre, Sydney Section, of the Institution of Production Engineers. We had hoped that Lord Nuffield would have been with us to-night, but unfortunately the very limited time for his visit to Australia made this impossible. Accompanied by Mr. H. M. Johnstone and our secretary, Mr. Steer, I was privileged to spend some time with him on the Monday before he sailed. He was very much interested in the formation of this Sydney Section and gave us a good deal of sound advice. We received to-day a cable from him sending us his greetings and good wishes. We feel very proud indeed to be associated with an Institution which has for its President such a man as Viscount Nuffield—one who commands the respect of the whole world of engineering—deservedly so from his success, his many benefactions, and his inspiring personality.

At this first meeting in Sydney it will be of interest to all here to-night if I gave some account of the Institution of Production Engineers. The Institution was founded in London on February 26, 1921, at a meeting held at the Cannon Street Hotel, and was incorporated on July 1, 1931.

THE INSTITUTION OF PRODUCTION ENGINEERS

The objects for which the Institution was established are : (a) To promote the science and practice of production engineering, and for that purpose to do any of the following ; (b) to hold meetings of the Institution for reading and discussing communications bearing upon the said science and practice or the application thereto or upon subjects relating thereto ; (c) to enable engineers to correspond and to facilitate the interchange of ideas respecting improvements in the various branches of the practice of production engineering, and the publication and communication of information on such subjects to members of the Institution and others ; (d) to establish scholarships, organise lectures, hold examinations, grant premiums, and prizes for papers and essays and by any other similar means to enlarge the knowledge and improve the practice of production engineering.

The first President was Max. R. Lawrence, M.I.Mech.E., M.I.A.E. He held office during the years 1921-23 and his good work was later carried on by : Mr. J. D. Scaife, M.I.Mech.E., A.F.R.Ae.S., 1923-24 ; Mr. W. L. Fisher, 1924-25 ; Mr. R. H. Hutchinson, 1925-27 ; Sir Alfred Herbert, K.B.E., 1927-29 ; Mr. Tom Thornycroft, 1929-31 ; Sir Herbert, now Lord Austin, 1931-33 ; Sir Walter Kent, C.B.E., 1933-35 ; Lord Sempill, 1935-37 ; followed, as you all know, by our present President, Lord Nuffield.

The Institution grew slowly, necessarily so, because the qualifications for membership are very high. There are various grades in which members of the production staff may be placed. The last annual report, for 1936-37, disclosed the following position : Honorary members, five ; ordinary members, 537 ; associates, 32 ; associate members, 587 ; graduates, 284 ; affiliates (not included in other grades), 26 ; affiliated firms, 35 ; total, 1,506.* For some years the headquarters of the Institution have been at British Industries House, London, but this year it had to face the problem of finding another location for its headquarters. The Council decided to acquire No. 36, Portman Square, and the President, Lord Nuffield, has made the generous gift of £2,500 to the Institution to meet the purchase price of the lease which has twenty-two years to run.

There are in England at the present time, the following very active sections and no doubt others will also be formed :—

				Founded
Birmingham Section	...	...	...	1927
Coventry Section	...	...	...	1922
Eastern Counties Section	...	...	...	1932
Edinburgh Section	...	...	...	1936
Glasgow Section	1930
Leicester and District Section	1934

* Now over 1,700.

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London Section	1929
Luton, Bedford and District Section	1929
Manchester Section	1930
Preston Section	...	...	...	...	1935
Sheffield Section	...	...	...	...	1933
Southern Section	...	...	...	...	1934
Western Section	...	...	...	...	1933
Yorkshire Section	...	...	...	...	1933
Birmingham Graduate Section	...	...	...	...	1933
London Graduate Section...	...	...	...	...	1934
Coventry Graduate Section	...	...	...	...	1935
Loughborough Student Centre	...	...	...	...	1936

Each of these sections usually holds seven to eight meetings a year at which papers are read by highly qualified production engineers, on matters of interest to all engaged in the industry and after the papers have been read discussion takes place. A number of these papers with discussions are printed in the JOURNAL which reaches members monthly and which contains a wealth of information, as can well be expected, coming from engineering centres such as I have previously named.

We feel that production engineering in Australia, and particularly in New South Wales, has now grown to such an extent, that a Section of the Institution in Sydney could play its part in the further development of the many great industries we have round us and in the establishment of many others.

It was through the efforts of a comparative newcomer to New South Wales, that we are here to-night. I refer to our secretary, Mr. Steer, no doubt well known to most of you. Mr. Steer is a Graduate of the Institution and for some years prior to coming to Australia was a very active member of the Birmingham Section. He was, I understand, quite surprised to find in New South Wales so many well established and successful production engineering works and felt that a Section of the Institution could well be formed from production engineers in Sydney.

It is to his untiring efforts and enthusiasm and the assistance given by Mr. Barrett, Mr. Blunt, Mr. Dear, Mr. Finlay, Mr. H. M. Johnstone, and Mr. H. O. Johnstone, and later Mr. Oliver, and the encouragement, guidance, and valuable assistance from Council and I feel that I must mention the General Secretary, Mr. Hazleton, that this Section has been formed.

We have had regular monthly meetings for some time now and a good deal of the spade work has been done, but very much still remains to be done. Our efforts have been somewhat handicapped through two of our very active members, Mr. J. Finlay and Mr. H. O.

Johnstone having to go overseas. However, we feel that though this may have put back the work here, we shall later benefit considerably on their return, through their contact with the Institution in England. We were very pleased to hear that Mr. Finlay was attending the Finance and Development Committee meetings in London, and we look forward to his return and the many helpful suggestions which we feel sure he will bring back with him.

For the first year of the Sydney Section, I was appointed President. However, I am afraid that I shall be unable to contribute very much to the Section as I also have to go overseas very soon, and this is probably the only meeting I shall be able to attend this year. We are indeed fortunate that our Vice-President, Mr. H. M. Johnstone, will be here to carry on and I am confident that his efforts on behalf of the Institution will yield very gratifying results. He will have the assistance of the following members of the Committee, Mr. Barrett, Mr. Blunt, Mr. Crane, Mr. Dear, who by the way is a very old member of the Institution, his membership I understand going back to 1923, Mr. Finlay, Mr. McPhee, Mr. Oliver and Mr. Perry, who are well known to you and who are keenly interested and actively engaged in production engineering. I feel that the efforts of these gentlemen will lead to a steady sturdy growth of this Section.

A list of papers to be read during the coming year has been prepared.

At the April meeting, "Progressing of Work Through Shops" (Mr. Barrett); May, "Manufacture of Electric Motors" (Mr. J. H. McDonald); June, "Case Night"; July, "Works Organisation and Control" (Mr. S. D. McPhee); August, "Recent Development in Press Work and Press Tools" (Mr. J. C. Oliver); September, "Selection for Vocational Training" (Dr. Martin); and in October, the General Meeting of the Sydney Section will be held. To-night the paper to be read is entitled "The Production Engineer and His Work" and we feel that in view of the very good work done by our Secretary, Mr. Steer, we are indeed pleased that he has agreed to read the first paper. Before closing, I would like to thank you all for your attendance to-night, and also to express my thanks to Mr. Johnstone, Mr. Steer, and the Committee for the assistance they have given me in the formation of the Sydney Section.

At the conclusion of the first part of the proceedings, Mr. Steer gave his lecture on "The Production Engineer and His Work."

THE PRODUCTION ENGINEER AND HIS WORK

Paper presented to the Institution, Sydney, New South Wales, Section, by J. M. Steer, Grad. I.P.E.

WHAT is a production engineer? This question is often asked, but, up to the present, he has never been fully answered. I would describe him as one who engineers production. In doing so, he must perform certain functions, some of which I will endeavour to describe to you.

It must be remembered that, while the technique used by the production engineer may be different for varying sizes of plants, the functions are essentially similar, so that, in considering this subject I ask you to bear this point in mind. In the smaller plants, the production engineer will perform many of the duties himself, and, in the case of the larger ones, the work will be split up into suitable proportions.

We in Australia have to consider that a number of our manufacturing establishments are much smaller in size than one meets in other parts of the world. As a matter of interest, I quote here figures taken from the Commonwealth Year Book for 1935-1936, giving the classification of factories according to the number of employees, as applied to New South Wales:—

Size of factory	Number of factories	Percentage of total
Under 4 	2,743	32
4 	32	8½
5—10 	2,200	26
11—20 	1,120	13
21—50 	998	12
51—100 	374	4½
Over 100 	334	4
	<hr/> 8,486	

The following figures refer to a similar position in England in 1934, and were published in our journal in Mr. George Still's Paper on "Management Technique."

15 March, 1938.

THE INSTITUTION OF PRODUCTION ENGINEERS

Size of factory		Number of factories	Percentage of total
1—25	...	103,730	77.4
26—50	...	11,571	8.6
51—100	...	8,113	6.1
101—250	...	6,830	5.1
251—500	...	2,421	1.8
501—1,000	...	949	0.7
1,001 and upwards	...	421	0.3
		<hr/> 134,035 <hr/>	

One other point ; when speaking of a production engineer, it does not necessarily mean that he is concerned with the production of an engineering commodity. In time to come, he may control the production of many other commodities, such as foodstuffs, clothes, etc., but for the purpose of this paper, we will consider the manufacture of some engineering product.

Planning for Production.

Consideration must be given to the type of product to be produced in regard to its quality and also its selling value on the market. These two features will be fixed by the sales department and the production engineer instructed as to the degree of quality required and also the price at which it must be produced. It then becomes his job to analyse his methods of production, so that the desired result can be obtained. It is also very necessary that he be informed regarding the quantities required, so that deliveries can be maintained. The standard of quality in any sound organisation is set and must be maintained, and it is the production engineer's job to ensure that the suitable precautions are taken to achieve this end. He must consider the suitability of material to be used, the various operations to be performed, and jigs and tools, so that the quality can be obtained.

In regard to inspection, which links up with quality, it is not always considered that the production engineer should control this section. Some concerns prefer to make inspection a separate department, which, of course, can be used as a close check on the production staff. However, the production engineer must, when planning his methods, decide at what different stages of production inspection must be made, so that large quantities of work are not completed and found to be scrapped, which scrap could have been saved if inspection had been made at an earlier stage. It is necessary, therefore, for these two sections to co-operate, so that inspectors and inspecting apparatus, etc., are available when required.

The price, or the cost of production, must be carefully studied, and attention paid to the various items that make up the final cost. Price paid for raw materials, rates paid for performing the operations, jig and tools' cost, etc., and many other points must be watched.

This brings us to costing. A well-organised costing system is most essential in any organisation, large or small. The information that is collected together and compiled illustrates to the production engineer his cost of production, and, by this means, he is able to follow his costs and so ascertain how he stands on the costs side. It is the work of the Cost Department to collect the direct labour charges from the Rate Fixing Department, the raw materials cost from the Buying Department, and then allocate the overhead charges. Overhead charges should be considered by the production engineer because they form part of his total cost, and, therefore, the same attention should be paid to effecting savings as would be done in the case of labour and materials charges. I was informed recently that one concern in this town had detailed an engineer to fully investigate all costs that go towards making the overhead charges, and, by this means, considerable saving had been effected. The need for control of this nature becomes more pronounced as organisations increase in size. I was connected for some two or three years with a manufacturing concern employing about 14,000 workpeople. They formed what was known as an Efficiency Department, which, apart from planning methods, fixing work rates, and numerous other functions, definitely investigated overhead costs. By this means, a large percentage of wastage was eliminated, which, in an organisation of that size, is difficult to control.

The production engineer must always allow in his production schedules for the manufacture of spares, where applicable. This is really a service to his customer, and, as such, should in every way be equal to the product first sold. The production engineer can be of good assistance in this regard, because, the manufacturing of spares and also the holding in stock of these, are his responsibilities. It should be possible for him to arrange for the stocks to be available directly the call is received from the customer, and in this way build up a reputation for servicing the manufactured article.

The question of interchangeability is most important to the production engineer, and this is where the efficiency of any organisation is severely tested. The production engineer, therefore, has to ensure that, where conditions allow, his products are produced from jigs at the start, thereby providing for interchange of parts when required.

Designs become obsolete so that provision must be made for the storing of jigs, patterns, etc., required for spare parts production. Remember that service to your customer plays a large part in your

business, and that it is up to the production engineer to make provisions in his planning to cater for such demands.

Plant.

Engineering shops vary considerably in the way they are equipped with the machinery for production, and, therefore, it is the problem of the production engineer to worry out the most economical way of producing the product with the plant available. In this respect, it is his job to keep himself acquainted with the modern equipment available, and to investigate new methods to ensure that he is not dropping behind in his own shop. New ideas are always being formulated and, therefore, unless he is adding to his equipment each year, or at least recommending the purchase of plant, then he is not doing his job.

In his consideration of the purchase of plant equipment, he can consider such in several divisions—plant required for an entirely new product; change in design; replacement of obsolete plant; and finally, plant for the non-producing sections of the works under his control. It is his job, therefore, to follow these avenues, formulate the reasons for such purchases, and place before his directors suitable proposals, which can be quickly followed. In the event of such plant being purchased, he will be responsible for its installation, and also the production from such plant, as guaranteed by the suppliers.

The maintenance of the plant should come under the control of the production engineer. He can then be well informed as to the limitations of his plant, both for allocating certain plant for future production, and also the lasting power of plant he has already purchased, which, of course, will help him in his future purchases. In large organisations, it is generally possible to have available a machine repair section, where machines, as they become less efficient, can be re-conditioned and used to replace other machines as the need arises. It is also useful to carefully conserve these machines, because very often, when planning production of new products in which arrangements are made for special equipment to be used, these spare machines can be utilised until the special equipment is ready. The management very often calls upon the production shop to do the impossible, and it is such points as these that allows the production engineer to perform the impossible.

Careful attention must be paid to the selection of the maintenance staff, because, due to the vast improvements in machine tools over the last few years, incorporating both electrical and hydraulic control, it is very necessary to have available one man at least who is a competent electrician, not merely a wireman, but one who understands wiring circuits and their functions.

Material.

The production engineer is responsible for producing the finished article ; therefore, it is his job to process the operation from start to finish, to a promised delivery date. It is essential, therefore, that he be charged with the duty of controlling raw material supplies. He must be well informed in regard to the state of the market, so that the necessary orders are issued in good time to avoid delay in starting production when the time arrives, according to schedule.

Furthermore, he has to study the characteristics of the various materials, having regard to heat treatment and machining. When planning his sequence of operations, he has to bear in mind the type of heat treatment required, time and cost, and also in his layout provide for suitable equipment and space. The machining or machineability of materials is one of the problems that engages the strict attention of the production engineer. He must pay particular attention to the processing of the various materials, and their reactions to machining operations.

Having regard to the foregoing it can be readily realised that, unless control of material supplies from start to finish is scientifically handled, considerable capital will be uselessly involved, which is not acceptable to the management. It will be generally agreed, therefore, that the man who is responsible for production, should have under his control the supply and movement of materials.

Design.

The question of the production engineer's connection with design is very debatable. Many engineers are of the opinion that the production engineer should be consulted in regard to the method of production of a new product before the drawings are issued to the workshops. By this means much time is often saved and also money, because, in most cases, designers are not shop minded and not *au fait* with equipment available. How many times in your own experience could slight alterations have been made without altering the efficiency or the selling power of the product and allowed of cheaper and quicker production ? We, as production engineers, have to produce the job as quickly and as cheaply as possible ; therefore, we must look after our interests by keeping in touch with the designing office. If we have with us to-night gentlemen who are interested from the designer's point of view, I hope that they will furnish us with their thoughts on this very vital point. There is no doubt at all that we must, at all times, work in harmony with the designing engineer. Certain shops do not welcome the designer, and some designers feel that they are losing their dignity by consulting the manufacturing section, and also will not allow the production men to view the designs until they are issued. I,

myself, feel, however, that closer contact is being made between these two departments, and with the desired result. Finally, I do not infer that production engineers should, in any way, criticise the design from the viewpoint of its marketing value, but purely from the angle of the method of production. I hope this phase of the production engineer's activities will promote some interesting discussion at the end of the paper.

Jigs and Tools.

The production engineer's interest in jigs and tools is important, because they are means whereby he can reduce his cost of production, if properly applied. The first consideration is "Does the work piece warrant a jig?" If so, what cost can be allowed so that the application of a jig will not make the job too expensive? Therefore, in planning his methods, he must make provision for the most suitable jigs. The actual designing side may be left to a jig and tool draughtsman, the production engineer just outlining the general requirements.

Having started the design of the jigs, tools, etc., he must ensure that the manufacturing of such equipment can be carried out in his establishment or, if this is not possible, make provision for the work to be executed by outside suppliers. I have found that most production engineers, although very much concerned with production, do show a great interest in their toolroom. Unfortunately, in this respect they are not always supported by their directors, it always being difficult to convince the men who hold the purse strings that money must be spent on non-producing equipment.

As far as the layout of the toolroom is concerned, this may be left to the toolroom superintendent, who will have studied his best ways and means. Heat treatment, which plays a large part in toolroom production, should be left to one man, directly responsible to the superintendent, which enables faults in the treatment to be more easily controlled.

Heat Treatment—Works Products.

Measuring equipment is most important, as by this means the production engineer can set the manufacturing tolerances, and know full well that he has equipment available that can be used to keep the workshop gauges up to pitch. In this respect the production engineer should make provision in his layout for the proper case of gauges, etc., and ensure that they receive periodical checking, according to the nature of the work and amount of use.

Ratfixing.

The department handling this item of production should be controlled by the production engineer. They are responsible for allo-

cating the allowance for the labour charge, which as part of the final cost, must be carefully set. The ratefixer himself must be a practical man and possessed of tact. It is advisable, where possible, for him at any time to be able to set to and perform any operation in the time that he sets. He must not let this side overrule him, however, otherwise he may tend to set longer times than necessary, which would defeat the object of his work. A good deal depends on him and on his accuracy of setting times, otherwise money will be lost, and no concern, after fighting for the order wishes to execute it at a loss.

Progressing of Work.

The movement of work through the shops from department to department and operation to operation, is most important. The progress department should be in possession of full details in regard to quantities, delivery dates, and proposed plans for production. It is essential, therefore, that such a department should be under the control of the production engineer. It is usual, according to the size of the concern, for one or more progress clerks to be moving round the shops during the day. A routine system is necessary, and it becomes the work of these clerks to ensure that this work is kept on the move. Their job is not always easy, however, because they have to deal with the various foremen, who sometimes resent being bothered and chased for the work pieces. It behoves the production engineer, when choosing his men for this work, to give careful consideration to the type, otherwise his organisation will not run sweetly. Unless each department connects up in the chain of production, time will be lost, over-expenditure created, and also loss of production.

Stores Control.

This particular function of the production engineer is very important because, if not carefully controlled, a large amount of money can be locked up in the stores, which applies both to raw materials and finished products. According to the type of manufacturing plans, so the problems of stores control varies; some plants have to manufacture a large variety of products, whereas others specialise on one type of manufacture where, naturally, the problems are much easier. Careful analysis must be made to determine the rate at which raw material must be ordered, which in turn will determine the amount of finished products in the stores. It is necessary for the production engineer to have some indication of demand, so that he can gauge his quantities. Another important consideration is the question of stores space. Careful watch must be kept to ensure that stores space does not unduly encroach on manufacturing space.

It is well worth while paying particular attention to the stores personnel. My own opinion is that the head storekeeper should be a man of good appearance, smart and tidy. You will then find that such a man will keep his charge in order, and so lessen confusion, which at all times is likely to arise. Remember that the stores man from time to time contacts your customers, so that he should be just as important to you as your salesman.

Personnel.

Before production can begin, suitable labour must be available, and it is the production engineer's lot to ensure that this provision is made. According to the size of the organisation, so the method of engaging labour for production differs. In large concerns a labour bureau is established, and requisitions are sent through to this department, which is in constant touch with the labour market. Smaller concerns cannot afford such a department, so that it generally falls to the production engineer to engage the necessary labour.

The production engineer is chiefly concerned with his "key men" and apprentices for the production shop, and, of course, the necessary draughtsmen, time-study men, etc., for the planning work. Particular attention should be paid to apprentices, as they are the men who will carry on in due course. Certain of them will become craftsmen, others will rise to positions such as foremen, time-study men, draughtsmen, etc. Now we should carefully watch these young men and ensure that, should they show willingness, all facilities are available for correct training, so that, as the occasion arises, new men are ready to fill more important positions. I am sure that if this point had been taken care of in the past, manufacturers to-day would have been in a much happier position. It is very creditable to note that leading engineering concerns in this country are paying more attention to the needs of training apprentices, thereby assuring themselves, or at least the industry in general, of a good supply of skilled labour in the future.

In the selection of labour the production engineer plays a very important part. It is up to him to engage labour that will assist him in the smooth running of his organisation, so that every care must be taken in the selection. Remember that everyone is human and must be treated as such, and, if maximum efficiency is to be obtained, this point must not be lost sight of when planning for production.

Conclusion.

Having thought over the many duties of the production engineer outlined in the foregoing, it is only natural that one should arrive at some conclusion. One readily imagines that the production

engineer must be an extraordinary being to perform so many functions. It does not necessarily follow, however, that this is the case. As I said at the beginning, according to the size of the organisation, so the magnitude of the production engineer's activities alter. In the larger concerns, he will have under his control various heads of the different sections of the production staff, who will be directly responsible to him. It becomes necessary, therefore, for him to be able to choose men for these positions whom he knows will perform their duties to achieve the desired result, which means that he must be a man who is capable of selecting men for such technical positions.

He must be a leader, and, as such, respected by his staff, by whom his work must be able to be relied upon. Success in any business is the result of teamwork, so that it is up to him to engage his assistants and train them to this end. Thinking and planning ahead of our requirements is most necessary if we are to perform the duties of our calling correctly. Improvement in methods must be made, and this is where imagination can play its part. The production engineer must have imagination, providing vision, and an analytic mind, which will enable him to improve the present for the benefit of the future. Imagination was once regarded as solely the function of the poet but to-day this view is no longer held. On referring to the Oxford dictionary, it will be found that imagination is defined as "the mental consideration of actions or events not yet existence," and this definition sums up very concisely the main functions of the production engineer.

Discussion.

MR. S. G. WHIGHT : I note that Mr. Steer mentioned, under "Tool-room," the setting of tolerances by the production engineer, so that gauges can be made. I would just like to query that statement. I think it is part of the functions of the designing engineer to set his tolerances on the parts, as he is aware of the functions for which he has designed them.

MR. J. M. STEER : Actually I think the point I meant to convey has been missed, or else I have not conveyed it very clearly. What I meant to infer was that any works must have a standard of measurements and it is the production engineer's job to see that such gauges, tools, or jigs which he designs can be set to these standards, so that he is able to work to the tolerances given in the design. Does that clear up the query?

MR. S. G. WHIGHT : Yes, thank you.

MR. J. H. HALL : I may have misunderstood Mr. Steer, but he inferred to me in his statement, that, for successful production, the production engineer has a department which hires the labour and hands it over to him to mould into what he originally wanted. Now I think that if that was the impression meant to be conveyed, the production engineer should "raise Cain." He is the man expected to turn out the product, and he should have the sole right to engage labour, or he should have an assistant who will engage the labour for him so that he can turn out production according to the demand of his products. Did I understand you aright when you said the Hire Department should be separate from the production engineer?

MR. J. M. STEER : Yes, but I particularly referred to large organisations. Imagine an organisation of, say 20,000 work people. The production engineer could not be interviewing labour every day or he would not be able to deal with the rest of his work. What actually happens in a plant in the production of a work piece is that certain types of labour are required, skilled, semi-skilled, and unskilled. It is usual for him to send forward a requisition to the Labour Bureau say for two skilled turners, a semi-skilled turner, and possibly a machine minder. It is up to the Labour Bureau to sort out these people from the labour available, and if it is a large organisation, possibly the second-in-charge would interview these men and finally select them. In smaller concerns I quite agree with Mr. Hall that the production engineer's activities are more general and he will definitely take some interest in the men he is engaging for his production.

MR. HALL : Is it possible for you to give any figures showing the percentage of inefficients engaged by the Labour Bureau ?

MR. J. M. STEER : No, I am not able to furnish such figures.

MR. E. C. PARKINSON (Section President) : Perhaps I may be able to throw a little light on that point. We have, for a few years, been manufacturing a fairly seasonal product. At certain times we have had to engage quite a lot of labour in a short period, and this brings home the point raised by Mr. Hall.

In the beginning, we handled this by having our production superintendents, or their assistants, engaging the necessary labour, but, unfortunately, through growing so quickly, we found that our superintendents and their assistants, instead of looking after production problems, were dealing with quite a lot of potential problems at the front door, so we had no alternative but to take the step quite a lot of organisations take when growing quickly into a larger concern. We started our Employment Bureau.

It is very difficult for one man to pick labour for another. We have now been operating under this scheme only a few weeks, but I should say that, over those few weeks, our labour turnover is a good deal greater than under the old method. This may be brought about by the fact that the labour is really inefficient, or it may be influenced by the fact that the production men have not engaged that labour. As yet it is too early to give an outline of the scheme in regard to its efficiency. It now appears that the production people have someone to whom they can pass the blame and any complaints. At present I cannot state whether this position will improve.

MR. HALL : The reason I raised the question is that I always had a Labour Bureau. I was always having arguments with the bureau about the type of men they picked. Their argument was that they picked the best offering and what else could I expect ?

MR. P. E. PAXINOS : The duties allocated to the various executives of a manufacturing organisation will vary according to the needs of individual plants, but I feel that, fundamentally, the production engineer has to do with the mechanical aspect of production and is not directly related to the engagement and supervision of labour.

A brief indication of the organisation finally decided upon for a factory employing about 500 men may be of interest.

The designing engineer is responsible for the design of the product. The production engineer is concerned with the mechanical aspect of production which involves such matters as the flow of the product, the design of tools, jigs, and fixtures, selection of equipment, and factory layout. The staff superintendent attends to the human aspect of production and the chief inspector is responsible for checking all work and rejecting what does not come up to specification. These executives are responsible to the works manager, who co-ordinates their activities. Design, determination of the methods and means

of production, staff supervision, and inspection, are specialised functions requiring the attention of specialists if the highest efficiency is to be achieved.

MR. W. E. CLEGG : For seventeen years I had experience with a company run by individuals. It was a registered company and the proprietors were personally in the business and running it and each one would put on any Tom, Jack, or Harry about the place when engaging labour, without much thought of whether he could do the job efficiently. If they liked the look of a man he was given a job and I can assure you the labour turnover was very high. As I came into a position of some authority, I tried to influence the situation, and to do my best to have the engagement of labour re-organised and only in the last five years met with any success in eliminating some of the trouble by a few people only having authority to engage labour. It was desired to get it down to one man being responsible for that particular job, with possibly an assistant to ensure continuity in his absence.

In due course I was given charge of another business, and the first step taken was to appoint a man in charge of that particular job. We took good care to pick out a man who had a good deal of experience, a man of mature years, but not so old that he did not retain some flexibility of mind and this has proved eminently superior. Over the last five years, up to two years ago, our average labour turnover—in fact I think it safe to say over the last ten years—did not exceed 4% and we have employed craftsmen of all kinds, in processing work and in the iron trade. Even under present conditions our average labour turnover does not exceed 5.5% over the last two years when tradesmen, as you know, are very scarce and there are any amount of temptations offered to take them to other places.

We call the man in charge of engaging labour "The Industrial Officer" and his office "the Industrial Office," and he not only engages labour, but takes care of the administration of awards and also of the discharging of any men. No foreman has the right to engage or discharge a man. He can suspend a man and refer the matter to the Industrial Officer for investigation. I have found, over a number of years, that foremen are the greatest cause of labour turnover in a plant, i.e., the man who is the first step above the workmen, leading hands and junior foremen, causes the greatest trouble with labour. These men are more recently appointed to their jobs and are anxious to throw their weight about and show their authority. We would not tolerate these men having anything to do with discharging labour. They generally pick on older men, valuable servants of the company, and endeavour to discharge these fellows and would do so if they had the authority. Now they can only suspend men and refer the matter to the Industrial Officer and have the case investigated.

THE PRODUCTION ENGINEER AND HIS WORK

You would be surprised how much this Industrial Officer knows about every man and his family, and there are over 750. If you were to ring up, out of idle curiosity, at any time, and ask him if he had a man called Jones working there, of such and such an initial, say Frank, he would answer "yes" if the man were employed there and that he has been working there for so long. If you ask if he is married, he will be able to tell you, also how many children, and so on.

He gets to know all details about the men, whether they are good craftsmen or not, not through personal knowledge, but through making exhaustive enquiry. Another very important aspect of this man's work, particularly as a company gets busier and busier, is the question of industrial disputes. He is invaluable in that respect and takes care with the men whom he engages.

I should explain that when labour is wanted, he does not only engage one man for any department. He will engage three men to be referred, say, to a foreman, if there are three available, moulder, fitter, or any other craftsmen, blacksmith, or pattern-makers. He will send at least three men whose reputation and training he is quite satisfied about. He is particularly interested in their home life and their general outlook, and I can assure you that if a man has a bad reputation, he takes care he does not get past the front door. In that way he keeps to a good standard all the labour being employed and this is an important aspect.

Another point of importance is the question of apprentices. This man takes care of apprentices, along with a production engineer and one other executive officer and the three are responsible for seeing that the right kind of youth is engaged, who has had a decent education—up to the intermediate Certificate and who is of good family—not necessarily a wealthy family; we are not interested in that. Generally, we find that a boy from a poorer family does better than a boy from a better off family, as he has to battle along and make his own future, whereas the other fellow is just out to put in his time as an apprentice and hopes later, as he knows people with influence, to get a better job and so does not have to depend on himself.

The Industrial Officer has an important job and it has been found necessary to supplement his staff to enable him to carry on the work properly; also he is getting on in years and it is necessary to give other men the opportunity of training in his work.

On our experience, we would never dream of allowing foremen, production superintendents or other members of the production engineering department or administrative staff to engage any labour. We believe this should be done by a man who sees that the employees conform to the general policy desired by the company and engage under all the rules and conditions which apply. In our case we are operating under 22 different awards, so that the production superintendent in his own department may be employing people under

five or six different awards, which necessitates careful handling, and it is doubtful, in these days of pressure, whether he has had the opportunity of acquiring the necessary knowledge of all these awards and also he has his own job to do. Hence, I strongly support a well-organised, well-experienced Labour Bureau to take care of this problem.

Before finishing, I would like to say that I would appreciate the opportunity, later on, of saying something about the formation of this section of the Institution.

MR. H. M. JOHNSTONE : I would like the opportunity of commenting on Mr. Hall's query and remarks. I heartily agree with Mr. Clegg's idea. It has been our experience, in a comparatively small concern, to have one officer employing all the labour, i.e. a superintendent, and it has become a very onerous job, and as time has gone on and the company has grown, it has become more so. As much responsibility rests with the person in charge of the labour department, I feel, as Mr. Clegg has said, that the man in charge of that section must be a man of wide experience and keen in sizing up men. I firmly believe if more companies of, say 300 to 400 employees, would only realise this and select such a man for this job, it would pay them handsomely. I make that statement because of my own experience on this question of labour selection. It takes up so much valuable time of the superintendent and foremen, whose jobs really are the supervision of labour after it has been obtained. The point, in my opinion, is to aim to have a specialist to engage all labour, definitely in large companies and as far as practicable, in small companies.

MR. S. G. WHIGHT : There is one point I might have mentioned earlier. When Mr. Steer finished his paper, he said he would like us to point out anything we considered had been missed by him in considering the work of the production engineer. I would like to suggest that Mr. Steer missed a point which I consider must come into the production activities, that is in relation to buildings, i.e., the extension of plant buildings. The production engineer need not necessarily be an architect or a designer of buildings, but I think he should be called in to consider this matter, and, in some cases, this question may arise from his own needs in regard to extension of machine tools, and the site on which he wants to put them. His needs in regard to the geographical situation of any proposed new buildings should be considered. I think that a very important point which Mr. Steer has not covered.

MR. J. M. STEER : I quite agree that this is one of the things which I did not bring into my paper. No doubt, when planning for production, this question would come up for consideration by the production engineer, particularly in regard to the lighting of his shop, which definitely does affect his production, and also the

conditions under which his work people are going to operate, all of which comes in for consideration in the layout of the building.

MR. E. A. MOLESWORTH: I would like to thank you for the opportunity afforded me of being here to-night, and for the outline given of the Institution and its activities. The last four years have had the pleasure of perusing the reports of the English Institution, and I am certain the formation of this Society here will fill a very long felt want in New South Wales and Australia, for production engineers.

In regard to the point mentioned by Mr. Steer with reference to the designer and the production engineer; in a small concern the designing engineer and the production engineer should be one and the same man.

Speaking of production engineering; I have been interested in production since 1910, and I feel that, in a small concern, as mentioned above, the duties of designing engineer and production engineer should be carried out by one man. When a concern becomes larger, the production engineer and the designing engineer are usually two, or perhaps three, different men, but, at all times, the production man should confer with the designing man, and, at the same time, if the designing man wants to be sure of production, he will confer with the production engineer. These two points definitely go together.

I listened with great interest to Mr. Hall and Mr. Clegg in regard to labour. There is no doubt about it, as a concern grows larger, neither the production man nor the designing man, has time to handle employment, and they should have a man to handle this matter, but I think they definitely should have say in the choice of the men engaged to take part in the production work.

MR. W. F. DAWSON: I would like to thank those responsible for admitting me to this meeting of the Institution. I feel we can all be of great help to each other. I would like to review the questions dealt with this evening. The first one was in respect to the fixing of limits for production work. There seems to be some doubt as to whom this should be given. Personally, I think it should be given to the designing engineer, as he is the man mainly responsible for the fixing of these limits. As we all know, limits vary considerably. For instance, take a set of manufacturing limits given for the manufacture of a certain product. The inspector generally has a different set of limits. That has been my experience. The production shop is tied down to a limit of, say, plus or minus .0005 to .001, and the inspector may have a gauge a little different, say, plus of minus .001 to .0015. That has been my experience, and, generally speaking, the limits are tied down, or laid, by the designing engineer.

In respect to the question re the hiring of labour. I have found that it is very trying to do the whole lot. When hiring labour and handing it over to a foreman, I generally find that things do not go too well. If the labour is just handed over to the foreman, and he has to get the men to work, he takes offence. I find it necessary perhaps, to interview the more important employees, particularly key men, who, I think, should definitely be selected by the management, but in respect of operators who have to work under the department foremen, I always seem to get better results if the foreman is interested in the hiring. Sometime ago, I handed a man over to a foreman, and later on had occasion to find fault with this man's work. What was the result? The foreman's attitude was "You hired him, you can take the responsibility." That is what I have found over a fairly long period of experience in this country. I have been with a shop employing over 400 men; at the present time we are only employing 70. If it is possible to throw some responsibility on to the foreman, he will look to it and you will find you will get better results than if the foreman has someone else on to whom he can throw the blame. This is difficult in a large concern, but in a small concern, like to many of the concerns in Australia, they cannot afford a hiring department, or even a superintendent, and the hiring is mainly done by key men. I find there are much better results obtained by interesting the foreman in the engaging of labour, and this throws a good deal of responsibility on to him as far as production is concerned. So far, I have found this is the best arrangement. Of course, in a very large concern, it is a different matter altogether, as a concern of over 300 men can carry, as I think Mr. Clegg suggested, an industrial department, that can select men and handle the question of labour quite efficiently. However, in a smaller concern, I think the personal contact of the man responsible in the shop for the man selected, has a great bearing on successful production.

MR. W. F. PAUL: I have listened to Mr. Steer and been very interested, but it struck me that, if he had used the term "works manager," instead of "production engineer," it would have been more suitable.

MR. J. M. STEER: The question of works manager crops up every time one discusses the production engineer. I think, myself, it depends, to a very large extent, on the size of the plant, on the layout and the executive officers. I have been in a very large concern where the works manager was directly responsible to the production engineer. In other concerns the works manager is known as the works director and the production engineer comes under his control.

In the case of weighing up the size of plant and the splitting up of the work that has to be done in arranging for the production of articles, the works manager, I feel, generally takes over little

more control than the production engineer, as he has under his control the administration side of other offices, the engineers, i.e. the plant engineers who are responsible for the maintenance and upkeep of various services through the works, and he has to take even a broader view than the production engineer himself. When you come down to a plant operating with, say, 100 employees, however, the works manager virtually becomes the production engineer as well.

MR. W. E. CLEGG : You will pardon me rising again, but I would like to take the opportunity of thanking you for the chance of being present here this evening and would also like to congratulate Mr. Steer on his paper.

With regard to the general outline given of what the activities of the Institution will be, I like the idea of prescribing certain papers for the year and picking out suitable gentlemen for taking care of these papers. I think this is an excellent idea and preferable to leaving the whole matter to guess work and later hoping someone will turn up each month to deliver a paper. To have a programme defined is much easier than to allocate the job to someone as the times comes along. I have been interested in the formation of this particular Institution in Australia for some time and have conferred with Mr. Steer as far back as fifteen or eighteen months ago. I have been doing all that is possible to interest the Institution of Engineers, Australia, in taking this proposed organisation under its wing and generally co-operating with it throughout Australia, as well as here in Sydney, and in that way endeavour to foster interest in your project, because in many ways the field of engineering is broadening, therefore, the engineers belonging to the Institution of Engineers, Australia, have so little in common amongst them, except in general professional interests. It seems difficult, however, to obtain the interest which one could expect in an Institution like this, where the men are intimately related through their daily avocations.

I can see here this evening the makings of a really good discussion on many aspects, and can imagine that, when you get down to such details as how to produce some piece in a shop, there will probably be 100 men present and each with a different point of view. Out of a discussion such as that, it is certain that each one must gain.

I must congratulate you on your enterprise in forming this Institution in Australia, which is very badly needed. There are two officers and a number of gentlemen here who were not born in this country, but have come out here. It is found throughout many engineering shops in Australia, men from overseas who are holding executive positions there. This is chiefly the result of a broader and more comprehensive training overseas. Particularly in the early days of engineering in Australia, we were rough and ready and it is only of late years when manufacturing industries

have developed and such men as Lord Nuffield and Henry Ford have identified themselves with large organisations, that re-organisation and co-ordination have taken place in production engineering in this country, as well as in others. In many ways we probably lag behind the older countries, largely on account of the size of works, although the figures given by Mr. Steer are not altogether surprising. A few years ago, I obtained information in the States, and it surprised me what a very small percentage of the total the large factories formed in the States, and how great a percentage there was of small factories. It was rather a shock to me, as one always imagines the States so big. However, statistics have proved that things are much the same there as in Australia.

I look forward, Mr. Chairman, when established here, to forming a branch in Newcastle, where there is an excellent opportunity of succeeding. The Institution of Engineers, owing to the very diversity of interests of its members is going, later on, to be anxious to co-operate with you.

You are going to attract a tremendous number of men in this community, who are intensely interested in production and, because of that close interest they will be, I am certain, very keen and interested in the activities of this Institution. I congratulate you on this, your first meeting.

MR. H. M. JOHNSTONE : I can assure you it gives me great pleasure to propose a vote of thanks to Mr. Steer for his very able and interesting paper. He has given us a very wide survey of the functions of the production engineer, so wide that one feels almost awed with the possibilities before us, when considering and organising any business and putting it on a sound economic footing. I think we should appreciate also in regard to Mr. Steer's paper that it is quite a difficult matter to give an opening paper at an inaugural meeting of a new Institute. That fact should be appreciated all the more in view of the splendid paper Mr. Steer has given us.

The vote of thanks to Mr. Steer was enthusiastically adopted.

THE OPERATOR—HIS RELATION TO THE MACHINE

*Address to the Birmingham Section by I. H. Wright,
M.I.P.E., M.I.Mech.E., Section President*

AS production engineers we are all interested in the possibility of expressing quantitatively all the factors which we handle, and, briefly expressed, the elements in production are the material, the organisation, the machine, the product, and though each of these is tied up in many ways with the other, and exact quantitative statement would be difficult to make for each of them independently, it is still desirable that every factor should be clearly defined.

The third element in the above series—the machine—can be fairly clearly defined so far as the machine itself and its driving motor are concerned, but what about the operator? He is certainly an important factor in the combined element which we call the machine.

Not many years ago machines were simpler, and little attempt was made at continuous production. Jobbing methods were generally used; the time efficiency of machine and operator were very low; and the product depended largely upon the skill of the operator. But the operator of this simple machine had such a variety of movements and muscular effort to make that the result was some degree of fairly natural fatigue, though the quantity of muscular energy expended in the course of a day was probably quite considerable.

Machines in those days were generally driven by belt, and little attention was paid to the power consumption so long as the power transmitted was sufficient to enable the machine to make the cut, or operate at a satisfactory rate for those days.

Nowadays with the greatly increased use of independent motors, the possible metal-removing capacity of the machine stands out as a prominent factor, and is more commonly taken into consideration than the similar fact in the days of belt drives.

The possibility of estimating machine production, together with many other factors which I need not discuss, has led to enormously increased production from machines, an increase which would have been quite impossible if the relation of operator effort to production had remained as before, so that developments in

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recent years have necessarily included the incorporation in the machine of many devices to reduce operator effort and to use such effort more economically.

I am suggesting to you this evening that this factor of operator effort can be dealt with to some degree quantitatively, as we already deal with speeds and feeds and motor horsepower.

We very glibly say that a machine is a means of saving and increasing the effect of human effort by the application of mechanical power, and it is certainly worth while to organise our ideas of the human being who is making the effort, so that we may not demand of him too great an effort. At the same time we should try to arrange that the fatigue and monotony arising from this effort should be minimised.

Also we must remember that an operator is a human and not a machine, and that his capacity varies from time to time, so that our quantitative ideas of high energy output must be low enough to avoid overloading him when he is a little below par; otherwise production may easily fall on this account. Though we may run an electric motor on an overload without serious damage, this is not safe with the human operator.

It is, of course, the case that the work of the operator on very many machines demands only very light muscular efforts, and in such cases the suitability and frequency of the movements become the leading considerations.

I propose to discuss more particularly those cases in which the operator has to move or lift a light workpiece and insert it correctly in the machine, and clamp it; also to make certain movement in the series or cycle of operations which the machine performs, afterwards removing the workpiece. This excludes, of course, fully automatic machines and magazine feeds where the work of loading the magazines is often rather a part of shop transport than of machine operation of the type I am discussing.

I submit that the manner of utilisation of the operator's muscular effort is more important than the amount of muscular effort required, and that the type of movements which require a natural muscular action will deliver more effective work in a certain time than if the movement is not of a natural type.

Though we talk of foot pounds per minute very definitely in the case of a driving motor, it would seem rather inhuman to express the muscular work done by the operator in similar units, but if we wish to express the operator factor in such a way that it can be compared with other factors in the production train, we must have some idea of its values. As I have already stated, any quantitative expression of the work capacity of the operator would depend upon the suitability of the movement and the physique and power of the operator, though I shall venture later to submit a proposal for this factor.

Discussing further the manner of utilisation of the operator's effort, one must, of course, begin by visualising the muscular system of the operator and forming definite views of his natural movements.

Such consideration will, I think lead to the general rule that muscular movement of external objects such as levers should generally be directed towards or away from the centre of gravity of the operator's body. By this means the force will have a minimum effect in disturbing the stability of the operator upon his feet and will demand less variation in loading upon each of his feet.

That is to say, it becomes a problem of stability. A bad example may be mentioned here, that is, the use of a pedal movement which involves the operator standing upon one foot whilst operating a pedal lever with the other.

Further to this question of stability, it must be realised that when the operator exerts a force on any outside body such as a lever or other part of his machine, his whole muscular system, from one foot clear to his grip on the lever and back from there to the other foot, is under muscular strain. If the movement he is about to produce must occur at a very precise moment, this strain is preparedness is very fatiguing, and whenever possible should be avoided. One remedy for this is to offer on the machines a counter-grip, so that this system of forces is from one hand across the shoulders to the other hand, and leaves the legs and lower part of the body of their normal duty of supporting the operator. Speaking generally, movements which must be performed at a precise time should never involve a considerable force but should be substituted by some power-operated device.

Precision efforts of this type, and involving suitably light efforts, are best dealt with by the application of a couple or closed torque such as the use of a knob of suitable shape and size for gripping. In some cases a pistol grip is useful and involves the smallest group of muscles.

Where it is quite necessary to use a movement of the foot in the operation of the machine, the effort should be kept low and arranged to be operated by the toe of the operator, his heel remaining on the ground. Another useful way of using the foot for very light work, where the two hands are otherwise occupied, is to have the operator sit on a fairly high seat and to operate a swinging stirrup lever by a swing of the foot.

The speed of movement required with an effort is also important, and should not be too fast for the natural movement of the operator, nor should it be so slow as to prolong unduly the time of muscular strain. In this connection, the inertia of the part to be moved has a considerable influence.

Speaking of quick movements brings forward the question of chucking and clamping, which in many cases involve a slamming action. These are very objectionable, as they lead to unnatural muscular efforts and may easily cause injury to the operator. For such purposes it is agreeable to note that the use of auxiliary power, such as compressed air, is increasing.

Further to this question of movement, it is desirable that each movement should be of a liberal extent. One often sees levers which have to be moved a very short distance to place them in, say, a neutral position. This involves a much greater strain on the operator than would occur if the movement were much larger, and the use of stops or gates for lever movements involving actual stopping at intermediate positions is of great advantage.

Presuming that the above suggestions as to manner and direction have been observed, I suggest that an adult male operator may be safely asked to exert the forces figured on the diagram.

It will be noted here that horizontal efforts, even though correct in direction, should only be of moderate value, whilst lifting efforts, insofar as they impose a direct load on the feet, may be considerable. You will note also that I suggest that a downward pull from a point above the shoulders may also be quite considerable. This point, I think, will be admitted by students of the Darwinian theory. Efforts away from the centre of gravity, however, you will notice are generally appreciably smaller than those towards the centre of gravity, as these forces involve less direct muscles than the main tension muscles of the arms, chest, and shoulders.

Movements round the centre of gravity of the operator, such as require a torsional type of strain on his body, must only occur in connection with very light efforts, as with heavy pulls or pushes they can be injurious.

But it still remains to discuss the frequency of his efforts, and the total amount of muscular work expended in a given time. As a basis, I propose that with about 250 lever movements to the hour, the sum of those should not exceed 1,000 foot pounds, that is, the pull in pounds, multiplied by the distance in feet, multiplied by the repetitions per hour, should not exceed this amount. Repetitions here includes all the various efforts made in one hour, with their respective movements. If the frequency of movement increases, then the total amount per hour must be reduced, as frequency has more influence on fatigue than the total quantity of work expended.

The foregoing includes only the muscular work required for the operation of the machine, and does not include such efforts as those required to lift the work in and out, but which obviously must have some consideration. If the piece is of reasonably small weight, the effort of lifting is reasonable, and being a free movement, can be

quite natural. Heavy or clumsy pieces, of course, must be dealt with in such a way as not to fatigue or strain the operator.

Having now discussed the capacity of the operator, we may turn to the provisions which can be made in the machine to keep the total muscular work done by the operator within the limits proposed.

As mentioned in the early part of my paper, a few years ago machines were very simple, and much effort was required on the part of the operator, but it will readily be admitted that in recent years the increase in production from machines has been accompanied by an increase in the provisions made for obviating the necessity of the operator having to exercise very great efforts, and also the location and arrangement of the controlling levers and members to which these efforts have to be applied has been the subject of serious thought, though I would again refer to one of my early statements that it is desirable that the various movements made by the operator should constitute natural exercises rather than a monotonous series of similar movements.

Amongst the features now quite common in all kinds of production machines, the following stand out for notice :—

Compressed Air. Largely used for the closing of chucks and clamping devices. This has the natural slamming action so necessary for this kind of work, and relieves the operator from dangerous muscular strains.

Auxiliary Motors for performing the idle movements of machine parts of considerable weight, such as would otherwise involve an appreciable effort continuing over an appreciable time ; on many smaller machines the same convenience is provided in the form of a mechanical quick-power traverse movement driven from the main source of power of the machine, and requiring only finger tip control by the operator.

Servo mechanisms are also used to some extent, whereby the operator effort to move a lever or other member is only nominal, and the part to be moved follows this closely by mechanical power, much in same way as on a steamship the movements of a small, light steering wheel are followed by a very powerful servo mechanism connecting to the rudder of the ship.

The balancing of vertical moving parts is also more thoroughly attended to, and a preference seems to be growing for the use of a compensated spring balance which has the very great advantage of keeping down the inertia effects of the motion and so allowing these to be made with the minimum of effort. The use of light metals for moving parts is also increasing for this purpose, though as men-

tioned before, inertia must be taken into account when considering the speed at which movements can be made and the efforts necessary to produce them.

My paper may appear to be rather narrow in its field, but it deals with a matter of great interest to users as well as designers of machine tools, and I trust that I have transmitted to you some ideas, and in some small way helped to consolidate your opinions on this subject.

Discussion, Birmingham Section

MR. J. A. HANNAY : It is surprising, if you get away from machines in the shop for a little time, when you return and see some of the latest things, how much you appreciate what is being done. I remember, when I started my apprenticeship I spent the first five years of my career as a machine tool maker. I think of the machines in those days—crude machines. The only good thing about them was the skill of some of the old mechanics who were able to bed slides. They made really crude jobs good by bedding the slides. When you think how crude they were, and think of the advances and improvements that are being made, you have to admit that the machine tool makers have done a tremendous amount to help forward the advances.

I was anxious to hear all that Mr. Wright was going to say, knowing that he would speak from the machine tool maker's side, and I think it does show how well the machine tool makers are handling their problem. They are forgetting this ripping and tearing off of material and actually studying our operators.

I would like Mr. Wright to have said a little more about the brain of the operator. I do not think we are yet taking enough advantage of the brain box. The next big movement will be to get the operators using their brains. It is the most wonderful thing in creation, the human brain. We do not want to look on a man merely as an operator of machines, but as a man with a brain box.

I think that if some of the welfare people get hold of this paper we shall hear more about it. I think they would just be delighted to get hold of it ; it is just the sort of thing they would like to crib. It almost makes one think that, possibly, when the time comes for another Employer's Liability or Factory Act, we shall see some of what Mr. Wright has put forward to-night.

MR. WRIGHT : Mr. Hannay and I remember better than many of you younger members, the time when machines were really more crude than I have said in my paper. I said they were simple machines but what you reasonably expected them to do in those days was to guide the tool in a reasonably straight line whilst the work was rotating on reasonably true and decently supported centres, and when a man was first put on to a machine he could not do anything with it until he became accustomed to it—friendly with it, as one becomes friendly with a horse. Good work was done only by the operator gaining knowledge and experience of the machine he was operating, that is, for really good work.

Mr. Hannay stated I ought to have said something about the operator's head. I think what I have been saying, if I have not referred to his head, has contributed towards the operator using his head. If 250 times an hour makes a strenuous effort, which nearly shakes his head off, it is enough to addle what brains he may have, and is not conducive to a quiet philosophizing about what is going on in the machine. Again, I think that, by making machines convenient, so as to require only moderate effort, the operator is encouraged to see what is going on in his work, take an interest in the actual operation which is going on, and in that way, if he is capable of taking an interest in the job, the encouragement is there, whereas if there is a lot of strenuous work, I consider that will discourage him from taking that interest.

MR. E. P. EDWARDS: As a machine tool maker, I am somewhat perturbed at the lines on which this paper was presented, especially after Mr. Hannay's remarks. I foresee the time when we shall have to supply with our machines a chart indicating exactly where the operator may put his hands, and the foot pounds of energy that must be applied in this, that, or the other direction. Heaven knows things are bad enough already for the machine tool maker.

I would like to ask Mr. Wright why, in his reference to auxiliary units, he did not mention hydraulic power? He told us a lot about compressed air, which to me is one of the most wasteful methods, requiring compressors, and all kinds of things such as long pipes. With modern hydraulics you can have what you require with far less trouble and expense.

MR. WRIGHT: I have to apologise to Mr. Edwards, and thank him for reminding me that I left out the use of hydraulic power for the movement of heavy parts. I regard hydraulic power as part of the machine itself. It is usually arranged not only to move things out of the way and bring them roughly into line again, but to do actually a complete cycle of movements. That is my general view of hydraulic movement.

MR. J. G. LEGGE: Mr. Hannay said that a very important point was the operator's brain and I agree. I still think that we do not make full use of the operators. We cannot turn them back into the old-style craftsmen if we do not ask them about their job. We are liable to design our machines to some extent, on our own experience, and on the experience of chief executives with whom we come in contact, and not sufficiently on what the operator thinks. I believe that was what Mr. Hannay had in mind, but I may be wrong. If it was, I do not think Mr. Wright answered it.

MR. WRIGHT: In the shops I have been concerned with, the operator is consulted, things are discussed with him, and I think that the designers of machine tools, the draughtsmen concerned with the finishing of the designs and issuing of drawings actually visit the

shops and discuss with the operators concerned, the charge hands, and so on, what they think about it, particularly when the matter in question is an improvement in some mechanism or part of machine which has been subject to some little criticism. Then everybody gets an opportunity but I think the general consensus of experience is that it is not much good. One man wants it shifting one way and another man another way. It is more difficult to get any constructive opinion and initiative than it is to get criticisms on the part of people in the shop, but I do not think it is because they do not have an opportunity.

MR. E. COOKE : Mr. Wright did not seem to have any great regard to the effort made by the operator, the principal effort the operator makes during the day, which is that of standing on his feet. I think it is up to machine tool designers to arrange their machines in such a manner that the operator can sit with a reasonable degree of comfort and operate his machine from a sitting position. One can rather visualise the centre heights of lathes being dropped by about a foot, with the view of the job being, as a result, very much clearer.

I remember, when I was an apprentice, if the foreman saw me sitting down at a machine he would use a few words which are not usually found in the dictionary. That is not the best way to get work done at all, and I should like to hear Mr. Wright's comments on that point of view.

MR. WRIGHT : Replying to Mr. Cooke about operators' feet, I mentioned once or twice in my paper that the operator was balanced on his feet, and he saw I had put my operator with feet well apart so as to get base and stability. I also mentioned that a force which involved a definite loading on the feet was to be preferred to those which were taking the load off one foot and putting it on the other, also that where effort had to be sustained for a short time it was very desirable that a counter grip should be supplied on the machine so that the operators could pull and leave his feet to support his weight for the time being, and strain would be taken by his arms, chest and shoulders.

I said in one place that it was desirable that the operator should sit where the work to be done would allow the operator to sit : he might sit with his feet well apart, but he should not sit on a high chair with his heels together.

If he is perched on a stool or any kind of support this takes the weight off his feet, or takes from his feet the responsibility for sustaining his stability whilst making the various movements. This is all in the direction of reducing fatigue. I quite agree.

Carrying Mr. Cooke's suggestion a little further, there is another thing I would mention. Many machines are so arranged that the operator has his toes against the machine before he can reach what he is going to do, which means he is hanging over. That is very

objectionable. The nearer the work to be done can be brought to the plane of the operator, the better.

If the machine is very wide or near to the ground, involving hanging over, it makes it very hard work for the operator. There should be room for the operator's toes to pass under the machine as far as it can possibly be arranged.

With reference to handles, I quite agree with Mr. Cooke that most handles are very badly shaped. The first handles that I remember on machine tools were turned from cow's horns, and you could not have anything except the standard shape. There were about three sizes. It seems to me that when people first took to manufacturing metal handles and bakelite handles and so on, they simply took the same form and gave very little consideration to it. In my early days as a designer, I got into trouble by making a different kind of handle which was partly used in those days and which conformed more to the natural grip.

Speaking about the knowledge of the forces in cutting, the operator of course, soon gets to know something about the force involved in stopping these rapidly moving chips, but from my experience he only has a vague idea of the forces concerned, though he probably thinks they must be quite dangerous. If we could only get operators to direct their attention a little bit to what is going on in the machine, then I believe that even the dullest of them would begin to take a technical interest in the operation that is actually being carried out.

MR. COOKE: I think more use of the operator could be made if an amp-meter were fitted on to every machine having a separate motor drive.

MR. WRIGHT: I have recommended, every time I have spoken about motor drives, that every motor drive should have an amp-meter making quite visible the power consumption at any moment, not only for the education of the operator, but to give supervisors an opportunity of seeing whether the set-up of tools is in good order, or whether it is time for it to be attended to. My argument has been there that if you knew in the middle of the afternoon that the tools were beginning to get blunt, you could stop and set them up, at night, for instance.

MR. E. W. FIELD: I have listened to all the remarks that have been passed this evening, and I have come to the conclusion that capstan lathe operators must be pretty wonderful people. I wonder if Mr. Wright has ever seen a really slick capstan operator on a light capstan making 100 parts an hour, each with eight or ten motions involved? If so, how can the foot pounds be calculated?

MR. WRIGHT: I hope Mr. Field will pursue that idea further in his own field, the capstan lathe. There is no doubt that on the small capstan lathe the operator gets in far more than the 250 movements an hour I spoke about. Whether the foot pounds of

work that he does in the time are more than 1,000, Mr. Field is much better able to say than I. Remember, the foot pounds consist of the pull exerted multiplied by the distance exerted multiplied by the number of times it is exerted, it is the sum of all those.

I think that, in operating the capstan lathe, only about two of the movements, the opening and closing of the chuck, would take some little effort, and moving the slide would take very much less effort than that, but the remainder of the 12 movements would be comparatively light movements, two or three pounds moving three or four inches. I am speaking now quite out of the blue. It is quite possible that there is a tremendous amount of movement, or that the work done in foot pounds in an hour might be very much more than the 1,000, but according to my recommendations, if the movements exceed very much 250 per hour, then 1,000 foot pounds should be reduced, because, in my opinion, frequency of movement may be as fatiguing as actually doing foot pounds of work. The argument, therefore, still remains with Mr. Field.

It would be very interesting, and it would either support my figures or give us a definite new basis, if Mr. Field would just think in detail through those movements and see how the foot pounds per hour would actually come out. My paper has evidently been quite successful! I have got Mr. Field thinking about the movements of the capstan operator in foot pounds per hour, and whether it is 1,000 foot pounds or not is a mere detail.

MR. ELKINGTON: One point which I think Mr. Wright has omitted to include in his calculations is that most production machine tools are fitted with fixtures or jigs, which also require a certain amount of clamping power from the operator. In many cases these are worked by heavy clamping methods, and add considerably to the ordinary operating of the machine tool. Has Mr. Wright included this also in his figures?

MR. WRIGHT: Yes. They have been included in the figure I gave if they constitute part of the duties of the operator who is running that machine. I have argued in certain places that a heavy clamping effort applied on the part of the operator is likely to be injurious, and some auxiliary power should be used. There is another way of getting over that which some jig and fixture designers know of, in clamping work in a jig, and that is not to try to do too much with one clamp. If you have a solid piece to put into the jig and try to clamp it with one clamp or pull, you have got to do as much work with one clamp as will hold that piece. If instead you had three clamps to operate, then the effort on each of those three would average one-third of the amount. You would get the same general holding of the piece, and the momentary strain on the operator would only be one-third of that applied to a single clamp. In any

case, if the jig is part of the machine, then the effort of clamping, raising the side of the jig, moving something out of the way to get the job in and out, those movements are included. If the piece is only small and light, then its lifting can be included, but its effect will be small. If the piece is fairly substantial, a cylinder block for a motor car, for example, then the operator should not be asked to lift it. Slides should be provided for inserting and removing it. What the operator has to do in the operating of the machine, apart from getting out of the way of traffic and so on, what the machine demands of him should be included in my figure. If you can revise that 1,000 foot pounds, after due thought, I shall be very glad to hear of it.

MR. STANDLEY : We have heard a lot about the operator, but nobody seems to have mentioned anything about the height of the operator. We have heard opinions as to whether he shall sit down, but not about his height. It makes a big difference when operating a machine whether the level is 6 in. lower or 6 in. higher. When you go through a works you often see a machine with a board or platform in front of it. Can Mr. Wright give us any information as to whether he has gone into the question of adjustable controls or anything in that direction?

MR. WRIGHT : I am about 5 ft. 6 in., and I consider, naturally, that is the virtually perfect height, and I design things that I think can be easily worked, but beyond that I am afraid that height is not considered. Usually it can be dealt with by a platform. It happens that one of the men who has to pass on my designs happens to be about 6 ft. high, and he quite commonly says, "These handles are very low!" and that kind of thing, but I say what he wants really is the wood blocks taking up so that he can stand 6 in. lower down.

There are some machines where the control levers are adjustable in position, but so far as I know not so much for height as for the particular direction or position that the operator wants, that is, the lever boss in this case has got a very fine clutch on its boss, and you can put them into engagement at the desired position. You can have a horizontal movement or an angular movement as you prefer.

As for vertical adjusting controls generally, I think that would lead to inconvenient complications.

MR. VERNON WELLER : Mr. Standley has stolen some of my thunder, but I do feel inclined to put forward one or two problems which the average production engineer, as differentiated from the machine tool maker, has often to deal with himself. Mr. Wright has mentioned one particular point, that is the energy expended by an operator in getting out of the way of traffic by his machine. From that point of view, the production engineer should have more

regard for the layout of machines, and give adequate working space. Some of the modern factories you can walk through and feel you are almost walking down the main street in a garden city on account of the amount of space which is available, but the number of such factories is relatively few.

Another point I feel strongly upon is the amount of energy which the average operator expends in stooping down to the workbox on the floor, picking up his components and putting them down again. Production engineers could save a lot of energy by providing stands at a useful height to minimise the amount of bending and stooping which takes place.

Another thing I notice on the average machine is the number of tools, gauges, micrometers and things of that kind, lying about in the suds and swarf. I consider a gauge tray is a necessity for practically every machine, as against the ordinary work stand which you see sometimes standing by the machine, and taking up valuable floor space. That is better than nothing at all, but I think something which is provided for the purpose at a convenient height where the operator can see without taking his eyes off his job would be better.


Regarding the point made by several speakers previously about operators not being able to make very intelligent criticisms or give the opinions desired from them, it is my experience that the average operator prefers the devil he knows to the devil he does not know. It may be something which is quite an improvement, and if you force him to try it he may, after a few weeks, come and tell you how much better it is, but before he has tried it it is no good.

In closing the meeting, Mr. HANNAY said that he did not remember a meeting where questions had come so naturally and so interestedly, and he thanked Mr. Wright, on behalf of the meeting, for having put such a paper before them and making it possible for so many to take part.

Mr. WRIGHT said that he had been waiting for years for an opportunity of presenting this subject for discussion. As he had said at the beginning, the President could select the subject of his Presidential Address, and he hoped he had given them something to think about, and if they could together arrive at more correct quantitative figures than he had given, then they would have done something.

DROP FORGING

*Paper presented to the Institution, Edinburgh and
Glasgow Sections, by J. D. Latta*

THE subject of this paper is a branch of engineering that the writer has been actively interested in for a considerable number of years. It is a very specialised branch and a most interesting one. Drop hammers have been in operation for forty years or more, although up till a few years before the Great War, plants were small and hammers comparatively so. 

The drop forging industry is really the mechanisation of the old blacksmith. Heavier forgings, more accurate forgings, and above all, cheaper forgings, were required and the drop hammer made it possible to supply the demand and so their use has grown enormously.

A drop hammer in its simplest form is just a weight with a half die attached to it, which is raised some feet in the air and allowed to fall by gravity on to an anvil. This anvil has the other half of the die fixed to it and by suitable guides the two halves of the die are made to strike together accurately. The piece of metal to be forged is placed in the bottom die and is made to take the shape of the dies by repeated blows.

This is the main principle of drop forging, but you will understand that great improvements have been made in drop hammers both in the method of operation and size.

Drop hammers with a falling weight of 5 tons are fairly numerous in this country, and there are a number of hammers of 10 tons and over. The power required to raise these heavy weights rapidly is considerable and it is done by steam or compressed air cylinders or by electric motors through friction gear of various kinds. As an indication of the power required, a 50 cwt. drop hammer requires an electric motor of about 75 h.p.

The falling weight is known as the tup, and it is usual to have the anvil 20 times the weight of the tup, so you can see that a very heavy anvil is required for a large hammer. This has led in recent years to the use of hammers having no anvil in the proper sense, the anvil being replaced by another tup which rises up from the ground and meets the falling tup with equal velocity. This type of hammer is limited in the forgings it can make, but it has the advantage of requiring no heavy anvil or large foundation.

Edinburgh, February 16; Glasgow, February 17, 1938.

DROP FORGING

Now, apart from the drop hammer, a lot of other plant is required in a drop forge. Saws and shears for cutting the metal into the correct size, furnaces for heating it, ordinary steam or air hammers for roughly shaping it where this cannot be done under the drop hammer itself, trimming presses to remove the surplus metal after the forging has been made in the dies, and any amount of other auxiliary machines.

In these days when so many machines contain drop forgings—motor cars, buses, aeroplanes, bicycles, tanks, tractors, submarines, ships, bombs, etc., it will be readily understood that the responsibilities of the drop forger are very great. Makers of machinery of all kinds calculate the stresses and strains on many parts of their machinery and rely on their suppliers to give them material up to specification. Drop forgings are the raw material of the machinist, so the drop forger has to study the strength of his forging as well as the shape.

The question of weight is an all important factor nowadays, and consequently the materials used are often of the highest quality to enable weight to be reduced without sacrificing strength. For the same reason most forgings are now heat treated.

Grain flow must be studied when designing the forging dies to eliminate kinks which would reduce the strength of the forging made from the dies, like a knot in an otherwise good piece of wood.

Then you turn to another aspect of the present day forging, the limits for size, machining limits; there must not be too much metal left for machining or too little. A motor car connecting rod is usually machined only at each end, and it is necessary after machining that the rods should be as nearly as possible the same weight, so that the engine will run smoothly. The forging dies for a part like this must be kept very accurately to size.

These points will illustrate some of the ideals that the drop forger aims at, at all events some of the technical ideals, because you will understand that drop forging is like any other business—men's livings depend on it, costs have to be looked at, and compromises have to be made between the ideal and the commercially possible.

I am going to describe shortly the sequence of events from the receiving of an order till its completion. The order arrives complete with blueprint, usually showing the finished machine part and the machining allowance required. This drawing is passed to the drawing office where the design of the die is decided upon. Expert knowledge and considerable experience is required to know just how the part can best be made. It may require one, two, or even more operations. An exact knowledge of the probable flow of the metal in the die is necessary, so that the dies work satisfactorily, because it does not follow that any impression you make in a die block can be filled with metal in a drop hammer. The die designer

must know what it is possible to do, so that the dies will make the forging satisfactorily and as cheaply as possible and make it so that natural grain flow of the bar or billet from which it is made is preserved. Of course, it may not be necessary to consider grain flow at all and experience and knowledge of a customer's requirements are the only guides.

If only a small number of forgings are required the simplest and cheapest die will probably be the most economical even although the speed of production is somewhat reduced. On the other hand, if thousands of forgings are to be made, the cost of the die will not matter much, a die with two or even three impressions costing a lot to make, will cost less per forging in the long run.

Other points to be considered by the die designer are the size of stock that will be used, the size of hammer that the forging will be made in, the shrinkage to be allowed for, and a hundred and one other small but important points.

Eventually all the drawings of the dies and tools are made and the die shop sets to work by more or less straightforward means to cut them. The impressions are roughed out on vertical milling machines, lathes, and, in some cases, automatic die sinking machines, the final shape being obtained by much hand work, chipping, grinding, or scraping.

I have unwittingly made this die sinking process sound easy, but, as you can imagine, it takes a lot of skill to slowly dig out an impression in a die block, with only the aid of a drawing and a lot of templates. One little dig below the depth and the die must be faced off and the work begun again. Automatic die sinking machines help a lot. A sensitive tracer passes backwards and forwards over a master die, and the milling cutter which is following the tracer cuts an impression exactly the same as the master, but it costs a lot to make a master die, so that this method is not used except where many repeat dies are required. Hand finishing is an art in itself, and much of the final appearance and accuracy of a forging depends on this.

While the forging dies are being made, the trimming tools will also be under way. The trimming tools are like blanking dies made to the outside shape of the forging at the parting line of the dies, and will trim off the fin or surplus metal left all round the forging when it leaves the forging dies.

After all the dies are finished, a lead is cast in the forging impressions, so that the die inspector who checks up all finished dies can with the aid of a contraction rule check up the forging impression. This lead is sometimes sent to the customer for him to check also.

Most dies are used hardened and it is necessary to take great care during this process, especially with large blocks. Hardening furnaces must be accurately controlled, both for atmosphere and tempera-

ture, long soaking heats are necessary before the quench and during tempering to eliminate strains, and accurate judgment is required to produce a block of the right hardness. Hardness is checked on Brinell machines and, of course, varies with the size of block; a small block may have a Brinell hardness of 400, whereas a large block may be as low as 320. A salt bath is sometimes used for tempering. After the dies are hardened they are polished a little in the impression to prevent the first few forgings from sticking and then they are ready for the hammer.

The forging dies are fixed into the hammer by means of a dovetail and keys, although on some types of hammer the bottom die is held in place on the anvil by four large screws which impinge on its sides. The trimming tools are fixed in a press near the hammer if the trimming is to be done hot. It is sometimes more convenient to do the trimming cold as a separate operation after forging, but this depends on the shape and size of the forging.

It is only those who have seen a drop forging being made who can appreciate the scene properly. It has been described as an inferno of heat and noise, but it is an inferno worth looking at. The forging squad at a large hammer of 3 or 4 tons consists of the forger himself who is the head man, the hammer driver who operates the hammer according to the signal or shouts of the forger, the furnace man who heats the bar or billet in the furnace and passes it over to the forger, the trimmer who trims the forging, and probably a helper if the forging is a heavy one.

Large and complicated forgings sometimes require to be reheated after partial forging so as to make them fill the die properly, or they may even require preliminary forging in a first operation die. Of course, both the forger and the hammer driver soon get to know the number of blows it takes to make a forging and, as the bars or billets are all the same size, the action of driving the hammer becomes almost semi-automatic, but the forger's job is a hard one calling for considerable strength and stamina; even with overhead runways and manhelps a lot of physical energy is required.

The tonnage handled by a forging squad is considerable, and the average output of a drop hammer in eight hours is about equal to its falling weight, that is to say a 3-ton hammer will make 3 tons of finished forgings in eight hours. This figure is a very average one, however, as it naturally depends on the shape of the forging.

Practically all drop forgings have to be heat treated, and this is carried out in large oven furnaces, where for the best results it is necessary to have the temperature automatically controlled by pyrometers connected to the burners. In some cases, notably aircraft work, recording pyrometers have to be used to make a record of each charge. I once heard an eminent Sheffield steel maker

describe heat treatment as an invention of the devil, and it is true that it can cause a lot of trouble, but with modern equipment in the way of automatic temperature control and laboratory checks, it has lost much of its terror. Testing is carried out after heat treatment, forgings are Brinell tested for hardness and perhaps one forging or a test piece from each charge is subjected to further tests for tensile, Izod, etc., depending on the class of steel and the specification.

Afterward comes descaling by pickling in hot dilute sulphuric acid, by sandblasting, or by tumbling, then the forging is straightened to special gauges if necessary and finally inspected and despatched to the customer.

I am afraid that this description of a drop forging being made must seem rather sketchy to you and of little practical use, but I hope that it has given you a general idea of the processes the average drop forging goes through.

Discussion, Edinburgh Section.

MR. PEET (Section President, in the Chair) : There are one or two questions I would like to ask Mr. Latta. What is the tolerance of temperature you usually maintain in your furnaces? Roughly, is it about 5% plus or minus?

Then, the submitting of lead proofs, which, I take it, you do, is quite an important point, from the customer's point of view too. Then, what inspection do you use for detecting cracks and flaws?

MR. LATTA : These automatic furnaces are quite capable of working to plus or minus 5°, or even to plus or minus 3°. That is Centigrade. The lead proof is a form of letting your customer see what his forging is going to be like, and the proofs are usually made by simply taking a ladle of melted lead and pouring it into the impression, after you have made your die. You then get two halves, as it were, and by carefully scraping the lead off until it is level with the top of each die, you get two perfect looking shapes. Actually they are hammered a little bit with a hand hammer to make the corners come up sharp, but there is really nothing very exciting about how the lead proofs are made. It is possible in some particular dies to make a solid lead proof, that is to say, one that is not in half, depending upon whether you can pour the lead in with the two dies together—with an open die it can be made that way. The lead of course comes out of the wrong size, that is, it is contraction size, and when you are measuring it up, unless it is a very small one, it is necessary to use a contraction rule and of course you have got to know what contraction to use.

Cracks and flaws : after a forging has been pickled it is a peculiar thing, that when it comes out of the hot water bath, any fairly, largish crack is very much more visible. Visual inspection is sufficient to detect this kind of crack. If you are uncertain, or if it is necessary to do anything more in the way of crack detecting, it is done on a magnetic crack detector. You take the forging and you lay it down between two magnetic poles, arranged on the machines, in the form of two blocks. You take the connecting rod and put the big end on one block and the small end on the other block, then you turn on the current, taking care to take your watch out of your pocket and put it away, because there is a lot of free magnetism about. Then you pour a solution over the forging containing black iron oxide and paraffin—when the slightest crack, that you couldn't possibly see with your eye, immediately becomes visible, just as though you had taken a lead pencil and marked it right across the forging. That is how you can detect very small cracks, but all

forgings are not put through crack detectors, because it has not been found necessary to do so. The inspectors can see sufficiently well and they certainly get to know where to look. The inspection is usually visual, sometimes with a magnifying glass, and sometimes with the naked eye.

MR. FROST : With regard to your remarks referring to an operator placing his foot on the pedal of a small hammer and pressing on it repeatedly, causing the hammer to repeat, in your later remarks you say an operator places his foot on the pedal and stands back. Which of these two methods is really correct ?

MR. LATTA : Undoubtedly it is a dangerous operation in many ways working a drop hammer. The forger holds on to the bar, while the hammer is going up and down quite close to him. It has not yet been found possible to devise any satisfactory guards from a safety point of view, but I have rarely heard of any accidents happening at the hammer, accidents seem to happen much more readily at the trimmer. With a large hammer, of course, the man definitely is a good deal further back, and certainly if he is not holding on to the end of the bar, or manipulating it in any way, he has no connection with the hammer and is able to stand aside.

MR. FROST : In the case of the trimming operation, the man is liable to be quite close to the operation ? Is there no guard on the machine then ?

MR. LATTA : No, there are no guards on the trimmer. In the usual way the forgings are very hot. The trimming press I showed you to-night is a hot trimming press and wouldn't be used for cold trimming work. If you are putting in a hot forging with a pair of tongs, you don't put your hands in the dangerous part of the press where the forging is, because it is all hot in there, so your hands are never actually near the tools. When cold trimming is being done it is a different thing. It is just like the ordinary press which is doing cold metal work. You have guards on it, and the operator cannot press on the treadle or work the press until his hands are out of the way.

A vote of thanks to Mr. Latta concluded the meeting.

Discussion, Glasgow Section.

MR. S. M. HARDAKER: One point that Mr. Latta did not touch upon was furnaces. What is his opinion of the best type of furnace, coal fired, gas fired, or electric furnaces for heating? Another point is the shape of the tup. How many of us realise how much the efficiency of drop stampings depends on the tup? Due to shortage of time, etc., I once made a simple rectangular one which was no use. We want to be very particular in the shape of the tup. With the rectangular tup I found to my horror that I did not get the same blow near the edges that I got at the centre due to a low centre of gravity. I had to alter the shape of the tup, because the shape greatly affects efficiency. Mr. Latta mentioned the ratio of weight of the tup to the anvil. I may have been slightly in error with regard to that matter. I wonder what Mr. Latta's experience is with steel for dies. My experience was, speaking now of a number of years ago, that we had no British steel to touch Austrian steel which stood up much longer. We find great difficulty in freeing the stampings from dies. Is Mr. Latta's experience different to that? I am interested in the laborious and tedious job of die sinking, which is evidently being tackled now by automatic machines. In the old days it was a matter for the vertical mill, and skilled craftsmen, chiselling and grinding out afterwards. I should like to ask Mr. Latta what he would expect as the average life of a die, i.e., the number of pieces expected from dies?

MR. LATTI: We have had experience of almost all the different fuels that are in use, ordinary coal fired furnaces, furnaces with pulverised coal, oil furnaces, furnaces run by producer gas, also furnaces run by gas from the town gasometer. The fuel you use to some extent depends on what kind of work you want to turn out. If you want an extremely good atmosphere in the furnace, and you are going to do extremely fine heat treatment, it is probably very hard to beat gas of some description. We use producer gas in our heat treatment furnaces and also oil, and we find them both very satisfactory, very easy to control; all our burners having automatic equipment. From the point of view of running expense, of course, the producer gas has it every time, but on the other hand it takes more installing. A producer is very easy to work and is quickly shut down. Oil burners can be installed very easily and are very controllable.

So far as the forging furnaces go, I think the most economical forging furnace available nowadays is the pulverised coal type. We have some at Ayr which work well, although I am inclined to

wonder whether, with all the apparatus in connection with it, it will continue to keep going satisfactorily. There are certain drawbacks to the use of this fuel, but they can be overcome with care. Some of our forging furnaces are oil fired, and they are perfectly simple. It is quite easy to get an oil burner to work satisfactorily, but from a cost point of view coal is very much cheaper.

We have not got any hand fired coal furnaces now, but we used to have some, and they made very good forgings. The furnaces are simple and they do not cost a great deal to run. They are not so easy to control as you cannot turn on or off. You naturally get better control of temperature if you have burners of some description on a furnace.

So far as the shape of a tup goes, I think that is probably left to a large extent in the makers' hands nowadays, although we have made many of our own tups—at least we have produced the drawings and had the tups cast. The great thing about the tup is to have it, roughly speaking, about one and a half times as high as it is broad. You can then make very reasonable forgings even if you are using dies of the multiple impression type, and the blow is off centre. If you have a square tup or one less than square, i.e., broader and not so deep, it rocks and the forgings will be offset.

Regarding steel for the dies, I have never had any experience of Austrian steel. I have had experience of American die steel, and a lot of experience with British die steel. They have had a lot of experience in America with drop forging dies, and they make very good die blocks indeed. We make equally good die blocks over here now, although the die block makers in this country are probably not so good at heat treating blocks as in America. You can get die blocks in America of any hardness you like. They are very good, very evenly and beautifully heat treated. Die block makers here do not succeed so well. We heat treat our own die blocks.

The life of a die depends to a very large extent upon the shape of the forging. Take the connecting rod dies I showed you, especially the double impression one, which had a roughing and final impression side by side. These dies will probably do about 5,000 to 6,000 before the rod becomes outside the weight limit. A single-impression connecting rod die block like that on the slide I showed you would probably do about 2,000, but again if you have a die of some simple forging, you may get many more. We have many dies which have made 50,000 forgings and very good forgings. On the other hand, we have had dies worn out after making 500 forgings. It is really very difficult to give you any indication of the length of life of a die, because it depends so much upon the shape of the forging and of course, the material it is made from.

MR. J. MCFARLANE: There was one branch which Mr. Latta rather skimmed over, but I realise, of course, that in such a wide

subject he could hardly deal with all the points here. I speak of the method of making templates. What special apparatus is used for the making of templates to form and dimensions to allow for differing contractions at the various parts of the dies? With regard to duplicators, there is no doubt about it that the Keller is one of the finest of duplicators. Has Mr. Latta had any experience of the Gorton machine for doing similar work? It is not automatic and does not cost nearly as much but it is very suitable for smaller ranges of work.

MR. LATT: When we are making templates for dies, the question of exact limits does not really apply. We make the templates for the dies out of $\frac{1}{16}$ in. thick sheet, or a little thicker for larger templates. All the templates are drawn out by hand measurement very carefully—after the sheet has been washed over with copper sulphate or some other thing to leave a coppery surface on it. Whoever does the template making marks it out very carefully with a fine pointed scriber. If it is possible he may use a rather more accurate sort of measuring instrument. To make templates for a connecting rod, for instance, one covering the long way of the rod, the template is laid off on a surface table, with the template held vertically on an angle plate, the centre lines will be marked off with a Starrett Brown & Sharpe height gauge. The rest of the template will be marked off by hand from the drawing.

The template, of course, is cut out on a small metal band saw or jig saw and is filed on the filing machine, or alternatively, ground on little electric grinders set on tables, but it is all done pretty well by eye, you might say.

I am afraid if you saw us making templates you might think it might be possible to make them more accurately, but it takes a long time to make templates for a connecting rod. It may take a man two or three days to make all the templates required, and they really are quite accurately made—they certainly cost enough money.

I have seen the Gorton duplicator. It is really for making very much smaller dies than we deal with, where you are only making small dies for small drop hammers. When it comes to the bigger size die, so far as we are aware, there is nothing to come up to the Keller machine. The Keller machine is very expensive, that is one drawback.

The other hydraulic duplicators which are made in America are not as good as the Keller and are nearly as expensive. So far as we are aware, there are no other machines made that do the job really well. I have seen most of the foreign machines which are used. Some of those that come nearest are made in Germany. I have seen them at work in Germany and they did not appear to me to be anything like as good as the Keller.

MR. McDONALD: With reference to the up-ending process, I have had occasion to examine up-ended forgings and when I had cross sections etched it was I who was upset. I found there was no symmetrical grain flow at all, largely because the diameter of the up-ended portion was out of all proportion to the size of bar used, the structure was very little different from that of a casting. What is the relation of the maximum size of mushroom head to size of bar used to make it so that it will give symmetrical flow? In cold shearing of billets, is there not a tendency to start cracks, particularly if there is a certain amount of weakness in the centre of the billet which is very frequent in these days of inadequate cropping of ingots? Is the coining process for the finishing of drop forgings making any headway in this country?

With regard to the double tup type of hammer with the ordinary type of anvil it is usual to have the deep impression on the top half of die—is it possible to have the deep portion in the bottom half with the double tup type and what advantage, if any, is obtained?

MR. LATTI: Regarding grain flow in upset forgings, if you upset a large amount of material into a flange, it is *you* who get upset when you look at the grain flow. The grain flow can go anywhere at all. It can wriggle about all over the place—in fact it does. It is impossible to upset a bar or billet satisfactorily if you are going to upset more than a fixed amount. Actually you may take a bar and you can upset it with perfect symmetry both so far as the grain is concerned and the dimensions of the upset, as long as you don't exceed an upset length equal to three times the diameter of the bar, that is to say, if you have a 1 in. bar you can upset a piece sticking out 3 in. long, and you can upset that into any size you like. You can make it about 1 ft. in diameter and the grain flow would be perfectly good, or you can upset that 3 in. length of 1 in. diameter bar to a flange 1 in. thick, and the grain flow will be perfect. If you go beyond that primary rule in upsetting, then you get crinkly grain. In that connection quite a good number of gear makers insist that their gears are to be upset not more than this three diameter rule. In the case of gears where you obviously require more than three times the diameter to make the forging, you require to use a greater diameter bar, and draw down the small part if you want perfect grain flow.

We make some gears now in which we first of all have to take a medium size bar and draw it down to a small diameter and then upset the big diameter of billet, the idea being to get the grain flow even all round the gear.

Cold shearing billets certainly puts considerable strain on the material. In some respects this is quite a good thing to do, for, if there is a weakness in the centre of the billet through piping which you

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would not see if the billet were only sawn off, you find it out. Billets after cold shearing always have to be inspected before going to the hammer to make sure they are sound. Of course, you could not expect to cold shear all high tensile billets simply because you would not be able to do it satisfactorily. You may completely shatter the steel. You just have to find out more or less by experience what steel can be cold sheared satisfactorily.

The coining process is an interesting one. It is usually a hot process. Unfortunately I did not have time to talk about it. It is a new process and it is a final forging process which is put on forgings. It applies specially to things like connecting rods which are required to be within close tolerances. This hot coining process is done with an accurately finished die put in a powerful press. You take the drop forging as it comes from the drop hammer, heat it up again, put it in the die, and press it accurately to shape.

This coining process can be done in a friction screw press or a crank press. The use of these is becoming more common nowadays. These new processes usually seem to start in America, because there they don't seem to mind buying huge expensive plant in order to produce one little forging, especially where they have a large number of these little forgings to make. Apart from hot coining for getting greater accuracy, cold coining is used to a considerable extent. Cold coining is simply squeezing down a forging with special blocks in a press to eliminate the necessity for machining on the sides of bosses, etc. You can cold coin down to a fine limit, but of course, the presses for both hot and cold coining require to be very powerful. To hot coin a connecting rod with perhaps 8 in. or 9 in. centres requires a press with a maximum pressure of somewhere in the neighbourhood of 5,000 tons and this is a big and also expensive machine. I find that the present day cost is about equal to the number of tons pressure multiplied by two and that gives you the answer in £'s. I have seen a good deal of this process and would like to see more. It is a process that will eventually come, because the finished product at the end is so very good.

Regarding deep impression dies, so far as the hammers without anvils are concerned, i.e., those with the two tups, the reason that you put the deepest impression on the top in an ordinary hammer is that the metal will rise up better because it is hotter on the upper surface. The forging which is being forged is sitting in the bottom die in contact with it. Naturally the part that is in contact with the die has a tendency to get cooler and the part sticking up in the air keeps hotter as it has only momentary contact with the top die. Quite definitely that is the only reason why the deep impression is put in the top die, so that when you come to these hammers with two tups you still have to put the deepest and most complicated impression on top. The piece of metal being forged is still on the bottom die

as in the case of the anvil type hammer, and the hottest part of the forging is still the top half.

MR. GEDDES : I would like Mr. Latta to give us his experience reagrding the material used in lifting the tups. There are leather belts and ropes in the old-fashioned drop hammer. There is always a weak link in the material used. I should like Mr. Latta to let us have his experiences also regarding the Board Lifter. What is the heaviest tup that can be used with a board lifter ?

MR. LATTA : The lifting belt, or the ropes, or whatever you use to lift the tup, are certainly things which give a bit of trouble, but in the old fashioned Brett hammer the lifting is done by hemp ropes and it is simply extraordinary how long these last. They last for weeks and months sometimes. The main part of the belt is usually separate from the part where it is actually tied on the tup, the connection is made with a lashing rope and drop forgers are rather like sailors, they have their own methods of tying knots. A good drop forger will tie the main belt or rope on to the tup with the lashing rope, in a peculiar way, so that there is less chafing of the rope. Instead of using rope, sometimes a complete belt is used, ordinary belting such as is used on heavy machinery, and by means of iron clamps this belt can be brought down and put through the tup and clamped and thus will last for a long time. It is doubtful whether belts are very much better than the older fashioned ropes. One thing about them is they cost a good deal more.

On board hammers, the boards require to be very special wood. You cannot have a board with a lot of knots in it. Usually they are made of maple, that being the hardest as well as one of the strongest woods, and a hammer board hammer needs this to give a satisfactory length of life. America is very fortunate ; there they can get straight maple boards which prove very good. You can get them in this country, too, although it is more difficult. A board hammer will possibly run one set of boards continuously day and night for months. On the other hand, it may last two or three shifts, because the apparatus for opening and closing the rolls which pinch the board is connected to the man's pedal and it is possible for him when he is working the hammer not to push the pedal down fully when opening the rollers, and instead of the board being completely released the rollers are still grating in it all the way down and the board gets worn out that way. I think the largest size of board hammer used in this country is about 5,000 lb. I have never seen a 5,000 lb. board hammer working, but I have seen a 4,000 lb. hammer running and that seemed to work quite well. One rather marvels that boards will lift this weight, for even 4,000 lb. is nearly 2 tons in weight.

MR. PATE : Would Mr. Latta tell us whether the use of guttering is effective in maintaining the size and thickness of forgings ? Per-

haps I should explain guttering is used to allow the die to maintain position when closed and thickness of forging to be constant. Guttering allows surplus metal to get out and allows the dies to come hard together. I have not seen it practised. Why? I think it ought to help to attain this "absolute" accuracy that we are all set upon.

MR. LATTA : The guttering that Mr. Pate describes is sometimes called backflash. It is put on the dies, of course, for the reason that Mr. Pate says, that we want to get all the forgings down as near as possible to the same thickness, and quite definitely if you are working with a good hammer and dies with the right size of stock and the forger knows his job, you can produce forgings that are not far off the same thickness. The gutter, of course, is made all round the impression and is simply there to absorb surplus metal and if you put too much metal in there so that your gutter is full, you cannot bring the striking faces of your dies together. Of course, if you don't give forgings enough blows the striking face of the dies won't be together and actually I should say that where forgings which are oversize for thickness have been made in guttered dies it is almost certainly due to the fact that the forger had not given them sufficient blows. After the forger has made a few forgings he gets to know accurately the number of blows it takes to make each and if you watch a man at work you will find that each forging gets almost certainly the same number of blows every time. The forgers are all on piece work and naturally they are not going to give any forging any more than just sufficient blows to bring it up. Of course, the inspectors in the forge shop who go round examining the forgings as they are made, check them up to see that dies are properly matched and also to take note of whether the forgings are right for thickness and the dies have been closing together properly. Generally speaking, I think you could say guttering is very reasonably satisfactory. We find we cannot make forgings sufficiently accurate without it.

MR. W. BUCHANAN : Has Mr. Latta ever used guided dies—dies which are guided into each other for accuracy? Why is it that in a lot of places you see dies with guides?

MR. LATTA : The question of guided dies is one which we have investigated at odd times and we have made dies with special kinds of guides or lugs just to guide them into each other for the last inch or so of travel, but generally speaking we find that on a heavy hammer it is impossible to make a guide sufficiently strong to stand the work. Even on a hammer of about 1 ton weight, when the tup is coming down, as you can imagine, if the hammer itself is out of line, no guide or projection on your die is going to divert suddenly a ton weight in less than 1 in. or $1\frac{1}{2}$ in. travel. You just can't suddenly move aside blocks like that. When we have tried it, as we have done in the past, we have almost invariably broken the guides

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however strong they may have looked at the beginning. Unless your hammers are very old fashioned and have very ineffective guides on them, you are practically forced to rely on the hammer itself to provide the guide between the two dies. I once saw the famous Krupp works in Germany. There they had a very old kind of drop hammer which looked like an arch form of steam hammer, with practically no guides at all. That is to say, the tup part just hung straight on the piston rod and was practically hanging in mid air. The bottom die had pins about 6 in. long which engaged with the top die. These long pins were much bevelled on the points to give them smooth entry into the holes on the top die, but it was a very crude looking affair and quite obviously these pins had suffered very greatly. It was a very large hammer and the forgings which were being made were only good because they had about $\frac{1}{8}$ in. of machining all over, and it did not matter if they were offset a bit.

MR. LANG (Section President, in the chair): I would just like finally to-night to ask you to accord Mr. Latta a very hearty vote of thanks for giving us such a fine lecture.

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